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Vehicle suspension system, particularly for road and off-road vehicles

The present invention relates to a vehicle suspension system, particularly for road and off-road vehicles, such as trucks, buses and military vehicles, including tanks, and first of all for those vehicles whose weight and dynamical loads vary within a broad range during the operating process.

The main function of vehicle suspension is to reduce vibrations transferred to a vehicle body by vehicle wheels. The suspension is a set of elements connecting the vehicle wheels with the vehicle frame or body. Suspensions of automotive vehicles are fitted with steel springs such as leaf springs, coil springs, torsion bars, as well as solid rubber elements and pneumatic springs and hydro-pneumatic elements.

Leaf springs are made of elastic steel flat bars. The leaf spring, supported in the middle and loaded on both ends, is subject to deformation and simultaneously works against the forces of elasticity.

Coil springs are made of steel spring wire. They are lighter and easier to assemble than leaf springs but unable to transfer side forces, hence additional elements are necessary to hold the vehicle axle.

Torsion bars are steel springs made in the form of rod, tube or flat bar pack, one end of which is anchored e.g. in a vehicle frame while the other one is twisted by an arm of a vehicle wheel.

Pneumatic springs are built in the form of two or three-fold bellow manufactured of synthetic rubber reinforced with cord plait and tightened in metallic holders. Pneumatic springs work utilizing pressure of compressed air contained therein. They are used in buses and trucks as well as in off road vehicles. There are also hydro-pneumatic suspensions, in which the elastic medium is a compressed gas contained in a chamber.

Further compression of the gas results from the action of a piston, which follows the movement of a vehicle wheel.

A vehicle suspension, according to the present invention, is a purely mechanical device. It features a compact and robust structure and it uses only standard springs, while it provides a characteristic, which betters that of hydro-pneumatic suspensions. Moreover, the construction of the suspension, according to the invention, enables its characteristic to be freely chosen through the choice of the geometric parameters of the mechanisms comprised therein.

The manufacturing technology of the suspension according to the invention is simple and inexpensive. Moreover, the suspension provides the possibility of the relative position between elements connecting the suspension unit with vehicle wheels and a spring to be freely adjusted.

The invention solves the problem of constructing a vehicle suspension of non-linear characteristic using springs of linear characteristic. By non-linear characteristic is meant non-linear and differentiable dependence of suspension stiffness on vehicle axle flex.

The object of the invention is to provide a new type of vehicle suspension system destined for new vehicles, particularly for road and off-road ones, which also can be assembled in existing vehicles during overhauls, e.g. in tanks, and which improves substantially the shock absorption within the whole range of dynamical loads and vehicle weight variations.

The essence of the vehicle suspension system, according to the present invention, is that it comprises at least one flat or spatial four-link mechanism, three kinematic pairs of which are rotational ones, while the fourth one is either a rotational or a sliding one, and the two links of said mechanism are made in the form of eccentric and one link is made in the form of eccentric or slider, wherein one link of said mechanism is coupled with a vehicle wheel, another link of the mechanism is coupled with a spring, and the whole mechanism is fastened to a vehicle frame through yet another link, to obtain a non-linear dependence of deformation of the spring on an axle flex.

A good result is obtained when said suspension system, as four links of its mechanism, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric, the latter being coupled rotationally with a disc, while the shaft and the disc pivot directly in a mechanism body. The body is fastened to a vehicle frame. The shaft, in turn, is coupled rigidly with a vehicle wheel arm, and the disc is coupled with one end of a spring, the other end of which is fastened to the body of the mechanism or directly to the vehicle frame.

In this arrangement, the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

A good result is also obtained when the suspension system, as its four links, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric which, in turn, is coupled rotationally with a disc, while the shaft and the disc pivot directly in a mechanism body, the latter being fastened to a vehicle frame. Besides, the disc is coupled rigidly with a vehicle wheel arm, and the shaft is coupled with one end of a spring the other end of which is fastened to the body or directly to the vehicle frame. In this arrangement the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

A good result is also obtained when the suspension system comprises a shaft fitted with a flange and an eccentric, the latter being coupled rotationally with an intermediate eccentric which, in turn, is coupled rotationally with a disc, while the shaft and the disc pivot directly in a mechanism body. The shaft is fastened to a vehicle frame with the help of the flange, while the intermediate eccentric is coupled rigidly with a vehicle wheel arm, and the body is coupled rigidly with one end of a spring the other end of which is fastened to the shaft or directly to the vehicle frame.

In this arrangement the axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

A good result is also obtained when the suspension system comprises two flat four-link mechanisms and a steel spring in the form of U-shaped torsion bar, wherein each mechanism, as its four links, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric, the latter in turn being coupled rotationally with a disc, whereas the shaft and the disc pivot directly in a mechanism body.

The body of each mechanism is fastened to a vehicle frame, and the shaft is coupled rigidly with a vehicle wheel arm, while the intermediate eccentric is coupled with one end of the U-shaped torsion bar the other end of which is fastened to the intermediate eccentric of the analogous mechanism of the suspension of the other wheel.

In this arrangement the axes of rotation of all the kinematic pairs of each suspension mechanism are parallel to each other.

A good result is also obtained when the suspension system, as four links of its mechanism, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric, the latter in turn being coupled rotationally with a disc, whereas the shaft and the disc pivot directly in a mechanism body. The body is fastened to a vehicle frame and the shaft is coupled rigidly with a vehicle wheel arm, while the disc is coupled with one end of a spring the other end of which is fastened to the mechanism body or directly to the vehicle frame.

The suspension is in accordance with the invention provided that the axes of rotation of all the kinematic pairs of the suspension mechanism intersect at a precisely one point P.

A good result is also obtained when the suspension system, as four links of its mechanism, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric which, in turn, is coupled rotationally with a disc. The shaft and the disc pivot directly in a mechanism body, which is fastened to a vehicle frame.

Besides, the disc is coupled rigidly with a vehicle wheel arm, and the shaft is coupled with one end of a spring the other one of which is fastened to the mechanism body or directly to the vehicle frame.

The suspension is in accordance with the invention provided the axes of rotation of all the kinematic pairs of said suspension mechanism intersect at a precisely one point P.

A good result is also obtained when the suspension system, according to the invention, comprises a shaft fitted with a flange and an eccentric, which is coupled rotationally with an intermediate eccentric, which in turn is coupled rotationally with a disc. The shaft is fastened to a vehicle frame with the help of the flange whereas the intermediate eccentric is coupled rigidly with a vehicle wheel arm. The mechanism's body is coupled rigidly with one end of a spring the other end of which is fastened to the shaft or directly to the vehicle frame.

The suspension is in accordance with the invention provided the axes of rotation of all the kinematic pairs of said suspension mechanism intersect at a precisely one point P.

A good result is also obtained when the suspension system, according to the invention, comprises two four–link spatial mechanisms and a spring in the form of U–shaped torsion bar, whereas each mechanism, as its four links, comprises a shaft fitted with an eccentric which is coupled rotationally with an intermediate eccentric, the latter, in turn, is coupled rotationally with a disc, whereas the shaft and the disc pivot directly in a body. Additionally, the body of each mechanism is fastened to a vehicle frame, and the shaft is coupled with a vehicle wheel arm, while the intermediate eccentric is coupled with one end of the U–shaped torsion bar the other end of which is fastened to the intermediate eccentric of the analogous mechanism of the suspension of the other wheel.

The suspension is in accordance with the invention provided that the axes of rotation of all the kinematic pairs of each of the suspension mechanisms intersect at a precisely one point P.

A good result is also obtained when the suspension system, according to the invention, comprises a shaft fitted with three eccentrics which are coupled rotationally with corresponding intermediate eccentrics which, in turn, are coupled rotationally with corresponding sliders, whereas the shaft pivots directly in a body and the sliders are sliding fitted in the mechanism body, whereas one of the sliders is coupled with a vehicle axle while the two others are coupled with a spring, the latter being fastened to a vehicle frame. The body is fastened to the vehicle frame.

The object of the invention is shown in the accompanying drawings, whereFig. 1 shows a vehicle suspension system provided with a torsion bar, intended for fastening to a vehicle frame,

with the help of a mechanism body, and the suspension mechanism shaft coupled with a vehicle wheel arm; Fig. 2 shows a vehicle suspension system provided with a torsion bar and a disc coupled with a wheel arm, which is fit for fastening to a vehicle body with the help of a mechanism body; Fig. 3 shows a vehicle suspension system provided with a coil spring and an intermediate eccentric coupled with a vehicle wheel arm, which is fit for fastening to a vehicle body through the shaft equipped with a flange;

Fig. 4 shows a vehicle suspension system equipped with a U-shaped torsion bar coupling two suspension mechanisms with the help of their intermediate eccentrics; Fig. 5 shows a vehicle suspension system in which the axes of rotation and the axes of symmetry of all the suspension mechanism links intersect at a precisely one point P; Fig. 6 shows a vehicle suspension system of the Mc Pherson type; Fig. 7 shows a vehicle suspension system equipped with a leaf spring; Fig. 8 provides an example of a suspension answer force F as a function of a vehicle wheel flex x.

Example 1

The suspension unit comprises a shaft (W) fitted with an eccentric bore chamber (MW). In the eccentric bore chamber (MW) of the shaft (W) pivots a pivot (C) of an intermediate eccentric (M), the other end of which pivots inside of the eccentric bore chamber of a disc (D). The shaft (W) and the disc (D) pivot directly in a body (K). An arm (H) is fastened to the pivot of the shaft (W). One end of a torsion bar (S) is coupled rigidly with the disc (D), and the other one is anchored in a vehicle frame. The entire suspension unit is fastened to the vehicle frame with the help of a flange (Z) at the body (K).

In this arrangement, the axis OW of rotation of the shaft (W) relative to the body (K), the axis OD of rotation of the disc (D) relative to the body (K), the symmetry axis OC of the eccentric (MW) at the shaft (W) and the overlapping axis of rotation of the shaft (W) relative to the intermediate eccentric (M), and the symmetry axis OM of the intermediate eccentric (M), and the overlapping axis of rotation of the intermediate eccentric (M) relative to the disc (D) are all parallel to each other.

Owing to said arrangement, the suspension features a strongly progressive characteristic, much better than that of the hydro-pneumatic ones. Its characteristic is differentiable in contradistinction to other progressive suspensions of jump characteristic fitted with a few in turns actuating steel springs.

The suspension gives the possibility to choose freely the suspension characteristics,

what is an additional advantage over hydro-pneumatic suspension whose characteristic is determined by the gas being used. The suspension features a combination of small deformations of the spring with large wheel flex, which lengthens spring's life.

Example 2

The suspension unit comprises a shaft (W) fitted with an eccentric (MW), said eccentric (MW) being pivoted in an eccentric bore chamber of an intermediate eccentric (M), whereas the eccentric (M) pivots inside of an eccentric bore chamber of a disc (D). The shaft and the disc pivot in a body (K).

A torsion bar (S) is fastened to the shaft (W), and an arm (H) is coupled with the disc (D). The whole suspension unit is fixed to a vehicle frame with the help of a flange (Z) at the body (K).

In this arrangement, the axis OW of rotation of the shaft (W) relative to the body (K), the axis OD of rotation of the disc (D) relative to the body (K), the symmetry axis OC of the eccentric (MW) at the shaft (W) and the overlapping axis of rotation of the shaft (W) relative to the intermediate eccentric (M), and the symmetry axis OM of the intermediate eccentric (M) and the overlapping axis of rotation of the intermediate eccentric (M) relative to the disc (D) are all parallel to each other.

The suspension features a very strongly progressive characteristic, since to a relatively small vehicle wheel flex there corespondes a relatively large angle of rotation of the shaft (W), and hence a large torsion of the torsion bar, in contradistinction to the suspension described in Example 1. During overhauls, the suspension may be assembled in existing vehicles, e.g. in tanks.

Example 3

The suspension system comprises a shaft (W) fitted with an eccentric (MW), wherein the eccentric (MW) pivots in an eccentric bore chamber of an intermediate eccentric (M), and the eccentric (M) pivots inside of an eccentric bore chamber of the disc (D). The disc (D) pivots directly in a body (K) and the body (K) is coupled rotationally with the main pivot of the shaft (W). An arm (H) is fastened to a pivot (C) of the intermediate eccentric (M). The body (K) is fitted with a bracket (WS) on which the coil spring (S) is being supported, the other end of which rests on a vehicle frame. The whole suspension unit is fastened to a vehicle body with the help of a flange (Z) at the shaft (W).

In this arrangement the axis OW of rotation of the shaft (W) relative to the body (K), the

eccentric (MW) at the shaft (W) and the overlapping axis of rotation of the shaft (W) relative to the intermediate eccentric (M), and the symmetry axis OM of the intermediate eccentric (M) and the overlapping axis of rotation of the intermediate eccentric (M) relative to the disc (D) must be parallel to each other.

The described suspension mounting to the vehicle frame makes it easier to use a coil spring, which is the most widespread kind of steel spring. The suspension may be assembled in existing vehicles, e.g. in tanks, during overhauls.

Example 4

An arrangement described in this example is a compound suspension system for two wheels on common axle. It comprises two four-link mechanisms and a spring in the form of U-shaped torsion bar, which works simultaneously as a stabilizer. The torsion bar is coupled rotationally with a vehicle frame through clamping rings (O) at the base of the letter U.

The suspension mechanism, as its four links, comprises a shaft (W) fitted with an eccentric (MW) which is coupled rotationally with an intermediate eccentric (M) which, in turn, is coupled rotationally with a disc (D). The shaft (W) and the disc (D) pivot directly in a body (K). The body (K) of each mechanism is fastened to a vehicle frame, the shaft (W) is coupled rigidly with an arm (H), and the intermediate eccentric (M) is coupled with one end of the U-shaped torsion bar the other end of which is fastened to the intermediate eccentric of the analogous mechanism of the other wheel suspension. In both mechanisms, the axis OW of rotation of the shaft (W) relative to the body (K), the axis OD of rotation of the disc (D) relative to the body (K), the symmetry axis OC of the eccentric (MW) at the shaft (W) and the overlapping axis of rotation of the intermediate eccentric (M) relative to the shaft (W), and the symmetry axis OM of the intermediate eccentric (M) and the overlapping axis of rotation of the intermediate eccentric (M) relative to the disc (D) are all parallel to each other.

Owing to the application of an U-shaped torsion bar both ends of which are coupled with elements of the suspension mechanisms executing both the rotary and the planetary motion, the bar is subject to complex stresses depending on the wheels position. In the case of identical flex of both the wheels, the arms of the U-shaped torsion bar are being twisted and simultaneously slightly expanded.. In the case of various flexes of the wheels, the part of the torsion bar constituting the base of the letter (U) additionally is being twisted. Thus, the torsion bar plays the role of both the main spring for two wheels and the stabilizer.

The suspension, similarly to those described above, features a strongly non-linear characteristic, also for the stabilizer.

Example 5

The suspension system comprises a shaft (W) fitted with an eccentric (MW), whereas the eccentric (MW) pivots inside of an eccentric bore chamber of an intermediate eccentric (M), which in turn pivots inside of an eccentric bore chamber of a disc (D). The shaft (W) and the disc (D) pivot directly in a body (K). An arm (H) is fastened to the shaft (W).
A torsion bar (S) is coupled with the disc (D), and the whole suspension unit is fixed to a vehicle frame with the help of a flange (Z) at the shaft (W).

The axes of rotation of all the kinematic pairs of the mechanism of this unit suspension intersect at a precisely one point P. In particular, the axis of rotation of the shaft (W) and the axis of rotation of the disc (D) (the latter overlapping the symmetry axis of the torsion bar) intersect at an angle A.

This arrangement gives the possibility to choose freely the angle A within the range of 0-90^0, which gives the possibility of a position of the spring relative to the wheel to be conveniently chosen. In particular, in the case the angle A equals 90^0, one obtains a suspension with a trailing arm and a longitudinal torsion bar.

The suspension features a strongly non-linear characteristic, which can be freely shaped through an appropriate choice of the geometric parameters of its mechanism.

Example 6

The Mc Pherson-type suspension system comprises a shaft (W) fitted with an eccentric (MW), an intermediate eccentric (M), a disc (D), and a body (K). The shaft (W) and the disc (D) pivot directly in the body (K), while the intermediate eccentric pivots on the shaft eccentric (MW). A radius arm (H) is fastened to the shaft (W), and a bracket (T) supporting a coil spring (S) is fastened to the disc (D).

The axes of rotation of all the kinematic pairs of the suspension mechanism are parallel to each other.

The suspension has a non-linear progressive characteristic and compact structure, typical for suspensions of the McPherson type.

Example 7

Not in FIG.

A suspension system fitted with a leaf spring has a shaft (W) fitted with three eccentrics (MW1, MW2, MW3), three intermediate eccentrics (M1, M2, M3), and three sliders (D1, D2, D3), whereas the slider set (D1, D2, D3) and the intermediate eccentrics (M1, M2, M3) mate the shaft eccentrics (MW1, MW2, MW3) respectively. The shaft (W) pivots in a body (K), and the sliders (D1, D2, D3) are sliding fitted in the body (K). The central slider (D2) is coupled with a

vehicle axis, and the leaf spring is fastened to the outer sliders (D1) and (D3). Eccentricity ratios of the eccentrics (MW1) and (MW3) are equal one to the other.

Moreover, the eccentricity ratio of each shaft eccentric (MW1, MW2, MW3) equals the eccentricity ratio of the intermediate eccentric (M1, M2, M3) which it mate.

The shaft eccentrics (MW1) and (MW3) are both rotated by certain angle A relative to the shaft eccentric (MW2). The proper choice of the angle A provides a non-linear characteristic of the suspension of the required progressiveness ratio.

The suspension maintains an important advantage of the leaf spring i.e. its capability to hold alone the vehicle axle.

A common distinctive feature of all the suspension systems described above is a non-linear and differentiable characteristic which provides an extraordinary adaptability of the suspension stiffness to variable static and dynamic loads, thus providing a smooth and stable ride within the whole range of the vehicle loads.

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